



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>G01N 15/08, 33/38, G01R 33/44, G01N 24/08</b>	<b>A1</b>	(11) International Publication Number: <b>WO 98/29731</b> (43) International Publication Date: <b>9 July 1998 (09.07.98)</b>
---	-----------	---

(21) International Application Number: **PCT/NL97/00719**(22) International Filing Date: **22 December 1997 (22.12.97)**(30) Priority Data:  
**1004915 30 December 1996 (30.12.96) NL**(71) Applicant (for all designated States except US): **N.V. KEMA [NL/NL]; Utrechtseweg 310, NL-6812 AR Arnhem (NL).**

(72) Inventors; and

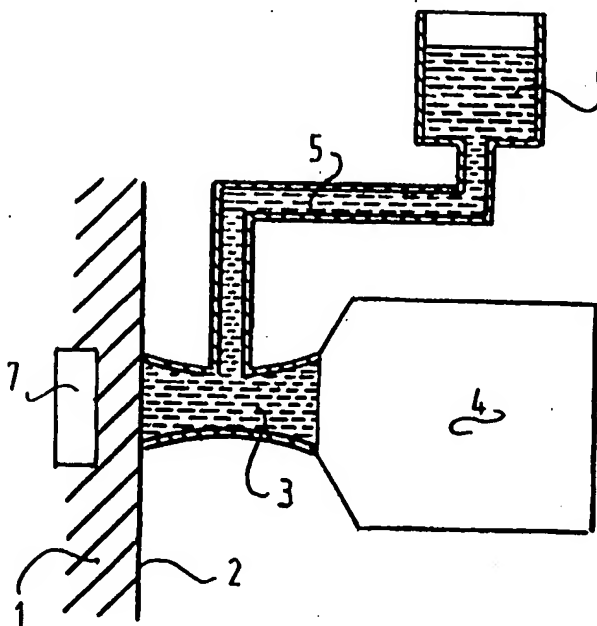
(75) Inventors/Applicants (for US only): **BLOEM, Pieter, Jan, Cornelis [NL/NL]; Balyeweg 12, NL-6874 AJ Wolfheze (NL). NETZELMANN, Udo [DE/DE]; Neunkirchenstrasse 182, D-66113 Saarbrücken (DE).**(74) Agent: **EVELEENS MAARSE, Pieter; Arnold & Siedsma, Sweelinckplein 1, NL-2517 GK The Hague (NL).**(81) Designated States: **AL, AM, AU, AZ, BA, BB, BG, BR, BY, CA, CN, CU, CZ, EE, GE, HU, IL, IS, JP, KG, KP, KR, KZ, LC, LK, LR, LT, LV, MD, MG, MK, MN, MX, NO, NZ, PL, RO, RU, SG, SI, SK, SL, TJ, TM, TR, TT, UA, US, UZ, VN, YU, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).**

Published

*With international search report.**In English translation (filed in Dutch).*(54) Title: **APPARATUS AND METHOD FOR MEASURING THE QUALITY OF CONCRETE**

## (57) Abstract

The invention relates to a method for measuring the quality of porous material, for instance concrete, whereby a body produced of said material is brought into contact with water, and that subsequently the migration of said water into said porous material is determined after which the quality is ascertained from the information thus obtained. As a consequence of said features it is possible to determine precisely the migration of the water into said concrete in which, with the help with the thus obtained information, statements can be derived relating to the permeability of the concrete, after which the remaining life time of the concrete can be estimated, and that possible reinstating measures, like the new application of an outside coat, the application of a paint coat or the injecting with plastics. The invention also relates to an apparatus for performing such a method.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TC	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

# APPARATUS AND METHOD FOR MEASURING THE QUALITY OF CONCRETE

5

The invention relates to a method for measuring the quality of porous material, for instance concrete.

Such a method is generally known.

According to said prior art method a cylinder is  
10 removed from said body to be examined, after which said cylinder is tested in a laboratory. Thus there is question of destructive testing.

Further, an ISAT investigation is known, in which the quality of the concrete, in particular the permeability thereof is determined by the quantity of water which  
15 is absorbed by the concrete. However, this concerns a rather inadequate method.

The aim of the present invention is to provide such a method for testing the quality of concrete which is not  
20 destructive, and which is sufficiently accurate. It is noted that the determination of the permeability of concrete has a large economic value. In particular in the case of existing buildings the quality of the concrete, in particular the permeability thereof, gives an indication of the remaining life time of the concrete, and the  
25 information can also be used as an indication for possible reconstructive measures.

Thus the present invention provides a method which is characterized in that a body produced of said material  
30 is brought into contact with water, and that subsequently the migration of said water into said porous material is determined after which the quality is ascertained from the information thus obtained.

As a consequence of said features it is possible to  
35 determine precisely the migration of the water into said concrete in which, with the help with the thus obtained information, statements can be derived relating to the permeability of the concrete, after which the remaining

life time of the concrete can be estimated, and that possible reinstating measures, like the new application of an outside coat, the application of a paint coat or the injecting with plastics.

5       The present invention also relates to an apparatus for measuring the quality of porous material, for instance concrete, characterized by a nuclear magnetic resonance apparatus for measuring the concentration and the distribution of hydrogen atoms in a body made from said  
10 porous material by means of nuclear magnetic resonance, and by means for bringing said body made of said porous material into contact with water.

Subsequently, the present invention will be elucidated with the help of the accompanying figures, in which  
15 are depicted:

figure 1: a schematic cross-sectional view of an apparatus according to the present invention which is used with the execution of a method according to the present invention; and

20       figure 2: a diagramm for elucidating the action of the apparatus according to the present invention.

In figure 1 a concrete body 1 is shown, which is on one side delimited by a surface to air 2. As discussed before, the permeability of the concrete changes during  
25 its life time; with increasing age the permeability for water increases. To measure this permeability use is made of a method for measuring the permeability comprising a vessel 3 which is filled with water. The vessel 3 is opened on one side, at which side it is located against  
30 the wall 2 of the body 1 to be examined. At the opposite side of the vessel 3 an NMR apparatus 4 is located. In this respect it is noted that this concerns only the probe of an NMR apparatus; it is very well possible that the excitation quills of the NMR apparatus are located  
35 elsewhere relative to the body 1 to be examined. By means of a supply channel 5, connecting the vessel 3 with a hopper 6 water is supplied to the vessel 3. Hydrostatic pressure may be used as well.

According to an embodiment use can be made of a pump for maintaining a pressure within the vessel 3. When the method is executed the following procedure is applied.

The apparatus described above is located with the  
5 open side of the vessel 3 against the wall 2 of the body  
1 to be examined. The body 1 to be examined can be a  
concrete building, for instance a viaduct, a bridge, a  
constructive part of a power station or another concrete  
construction. Subsequently, at a time  $t_0$ , water is supplied  
10 from the supply vessel 6 to the vessel 3 after which the  
water starts entering the concrete. The speed with which  
this entering process is executed is of course dependent  
of the permeability of the concrete. It is noted that  
normally already a certain amount of water is present in  
15 the concrete. This water will give rise to an NMR-signal  
 $S_0$ .

This amount of water comprises the so-called cristal  
water of the concrete, whereas it is not necessary, but  
very likely, that as a consequence of the normal humidity  
20 of the air "free" water is present in the concrete.

For measuring the water concentration in a volume 7  
located in some depth under the surface, use is made, as  
stated before, of an NMR apparatus. Such an apparatus is  
known per se, for instance for medical applications. The-  
25 rein such an apparatus is used for localising  
irregularities in a living body to be examined.

In the present application such an NMR apparatus is  
used for determination of the density of water, differen-  
tiated to place and time in the concrete.

30 To make things more clear figure 2 shows the signal  
of the NMR-apparatus at a certain location in the  
concrete as a function of time. At a time  $t_1$ , an increase  
of the signal is observed due to the arrival of some of  
the supplied water in volume 7. At the time  $t_1$  the  
35 increase of the signal and the shape of the curve are  
used to estimate the quality of the concrete. It is noted  
that by means of an NMR apparatus a constant magnetic  
field is applied onto which is superposed a secondary

magnetic field varying in time and location. The H-atoms which are influenced by the magnetic field configuration mentioned above give thereon a certain reaction which reaction is measuring by means of the detection quills  
5 (probe). By varying the distance between the NMR probe and the surface of the body to be examined it is possible to scan certain areas of the concrete body. Thus it is possible to obtain a depiction of the concentration of the H-atoms, and thus the H<sub>2</sub>O-molecules as a function of  
10 depth, the lateral coordinates and time. Thus, the present invention allows to obtain a three-dimensional depiction in the time of the migration of the water; thus, an image can be made of the permeability of the concrete after which statements can be drawn relating to  
15 the quality of the concrete.

It will be clear that besides for concrete the present invention is also applicable to other porous and permeable materials.

Further it is noted that the humidification of a  
20 part of the surface can also be made by other means.

**CLAIMS**

1. Method for measuring the quality of porous  
5 material, for instance concrete, **characterized in that** a  
body produced of said material is brought into contact  
with water, and that subsequently the migration of said  
water into said porous material is determined after which  
the quality is ascertained from the information thus  
10 obtained.

2. Method according to claim 1, **characterized in**  
that preceding to the bringing into contact with water,  
initially the distribution of the water already present  
in the porous material is determined.

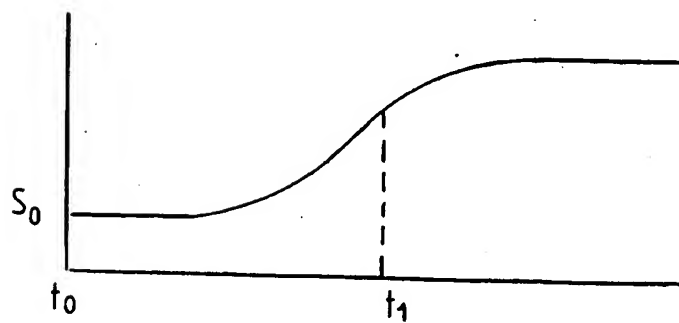
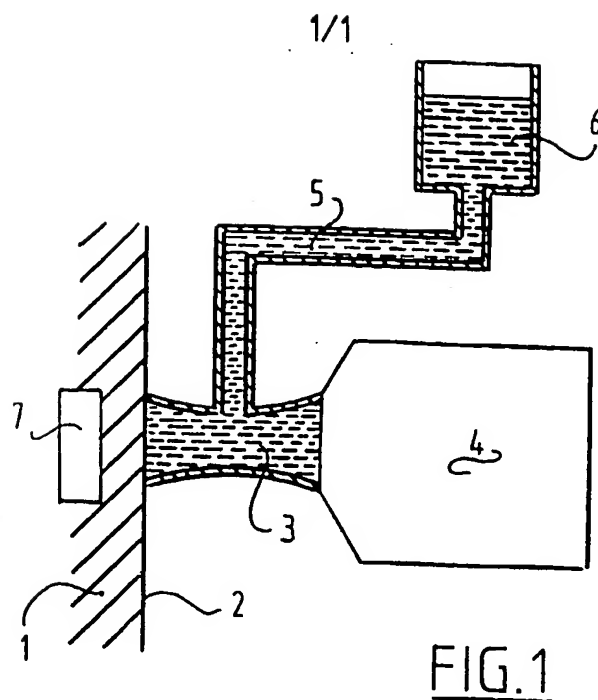
15 3. Method according to claim 1 or 2, **characterized**  
in that the determination of the distribution of the  
water takes place by means of the localisation of hydro-  
gene with the help of nuclear magnetic resonance.

4. Apparatus for measuring the quality of porous  
20 material, for instance concrete, **characterized by** a  
nuclear magnetic resonance apparatus for measuring the  
distribution of hydrogen atoms in a body made from said  
porous material by means of nuclear magnetic resonance,  
and by means for bringing said body made of said porous  
25 material into contact with water.

5. Apparatus according to claim 4, **characterized in**  
that the apparatus for supplying water to the body made  
of said porous material comprises a vessel of which at  
least one side is open, and which is arranged for brin-  
30 ging into contact with a plane of said body.

6. Apparatus according to claim 5, **characterized in**  
that at least one detection element or excitation element  
of the NMR apparatus is connected with the side of the  
vessel, opposite the open side of said vessel.

35 7. Apparatus according to claim 6, **characterized in**  
that the vessel is connected with an apparatus for sup-  
plying water to said vessel under super-atmospheric  
pressure.

FIG. 2



# INTERNATIONAL SEARCH REPORT

Inte Application No

PCT/NL 97/00719

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G01N15/08 G01N33/38 G01R33/44 G01N24/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 979 390 A (SCHUPACK) 25 December 1990 see abstract	1
A	see column 11, line 56 - line 65	
	see column 12, line 10 - line 23	7
Y	see column 13, line 17 - line 34	
	see figure 8	3-5
Y	US 5 055 787 A (KLEINBERG) 8 October 1991 see column 1, line 18 - line 21 see column 8, line 10 - line 13 see column 8, line 25 - line 30 see column 8, line 35 - line 43 see figure 1	3-5
A	US 4 291 271 A (LAUFFER) 22 September 1981 see column 1, paragraph 1 see column 1, line 25 - line 29 see column 4, line 41 - line 59	3,4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"Z" document member of the same patent family

Date of the actual completion of the international search

18 March 1998

Date of mailing of the international search report

25/03/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Thomas, R.M.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Publication No

PCT/NL 97/00719

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4979390 A	25-12-90	CA 2003659 A	01-06-90
US 5055787 A	08-10-91	US 4933638 A	12-06-90
		US 5055788 A	08-10-91
		US 5023551 A	11-06-91
US 4291271 A	22-09-81	NONE	